The Air Line Pilot

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The Human Eye At Best Has Built-In Limitations That Make It A Poor Collision Warning Device

By Dr. Walter F. Grether, Aero-Med. Lab. WADC

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Whether you are the pilot, another crew member or just a passenger, you probably feel safest when the weather is CAVU and visual flight rules are the order of the day. But there is one type of accident for which your chances go way up when the weather is fair. That is the possibility of a mid-air collision.

IFR procedures are designed to keep you a safe distance from other aircraft. Under VFR you are depending on your visual powers and alertness for safe separation. Human vision is a remarkable and wonderful sense. But unfortunately it has certain weaknesses which make it unreliable as a collision warning device. This article describes the most important weaknesses of human vision as they relate to aircraft collisions. This information may help you to reduce your chances of colliding with another aircraft under VFR conditions.

Before digging into the subject of vision itself, let's take a closer look at the mid-air collision problem. Both military and civilian aviation have become increasingly alarmed about mid-air collisions and are working hard to find solutions. In November, 1955, the Civil Aeronautics Administration and the Illuminating Engineering Society jointly sponsored a symposium on mid-air collisions, held at Indianapolis, Indiana. From the papers presented at this symposium we can conclude that:

▶ Mid-air collisions and near-misses are on the increase because of increasing flight speeds and the density of aircraft traffic.

▶ Most collisions occur during daylight hours in VFR weather.

▶ A pilot may fail to see another aircraft on a collision course in time to avoid it, even though he is looking outside (rather than at his instruments) and visual conditions appear to be favorable.

It is obvious that a pilot cannot see an approaching aircraft if it is obscured by clouds or haze. Similarly, we cannot expect him to see an aircraft, which overtakes him from the rear or approaches from some other direction to which he is blind (above, below or behind a windshield post). But with clear air, daylight and an approaching aircraft not hidden by a blind spot, why can we not depend on the pilot's vision to detect the other aircraft in time to avoid a collision? In most cases, of

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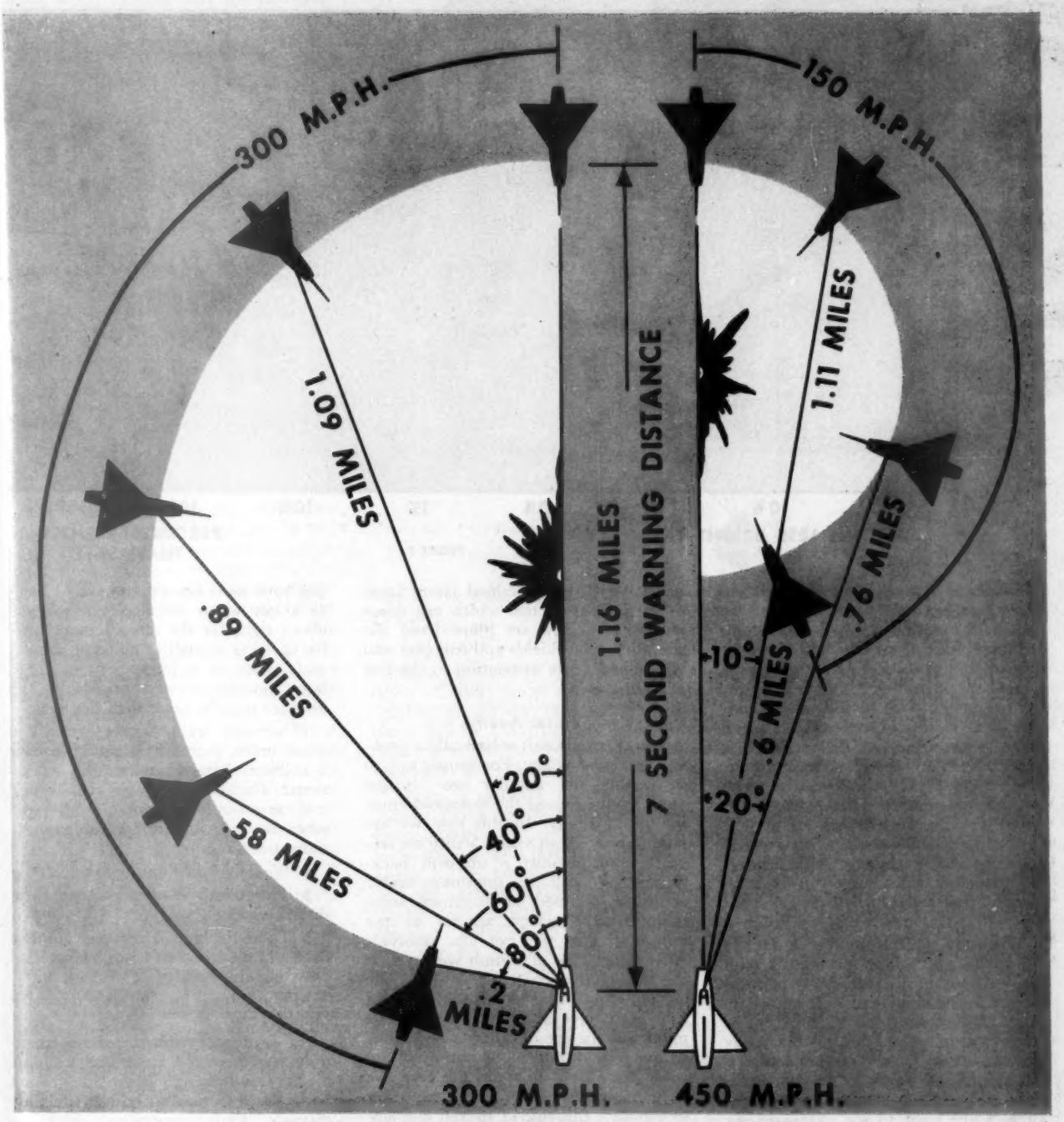


Fig. 1. Distances at which other aircraft would appear seven seconds before collision for the two-speed combinations shown.

course, one or both pilots will see the other aircraft in time to take evasive action. But there can be, and are, cases where even though the pilots in both planes are alert, their 20/20 vision is not good enough to avoid a collision. Let's see what there is about human vision which permits this to happen.

Seven Seconds

First, let's examine the question of how far away a pilot must detect another aircraft in order to avoid a collision. There is no easy or single answer to this question. The answer depends on several variable factors. There is a time lag for the pilot to make a decision. There is a further time lag for the aircraft to be displaced from the line of flight. Assuming we have a large aircraft, seven seconds is a rough but reasonable estimate for the combined pilot and aircraft lag. The other variables are the speeds of the two aircraft and the flight path angles.

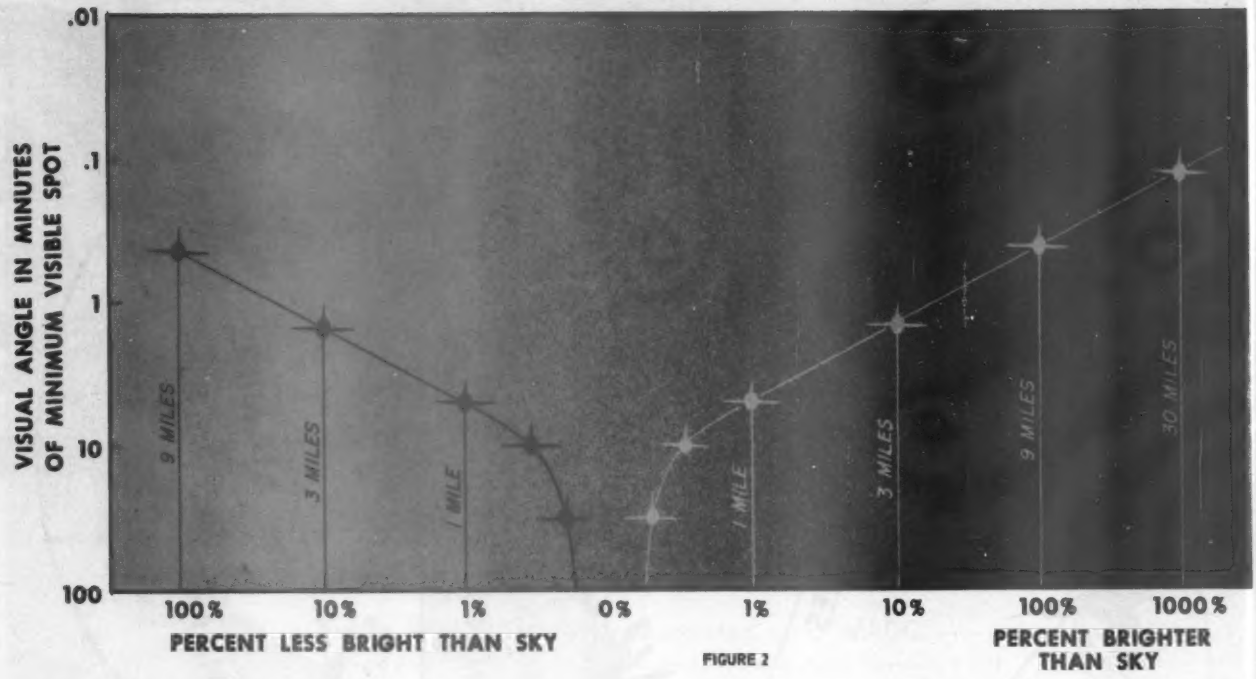


FIGURE 2

Distances between aircraft which will give seven seconds warning time, are shown in Figure 1 for two speed combinations and a variety of flight path angles. Both speed combinations give a closing speed of 600 miles per hour for a head-on approach. At this rather conservative closing speed the head-on seven seconds warning distance is 1.16 miles. For many of our modern jets the closing speeds, and therefore the seven seconds warning distance, would be about double these values. Figure 1 further shows how the zone of greatest collision hazard changes with relative aircraft speed. The faster you fly, relative to other aircraft, the less you need worry about aircraft off to the side.

There are quite a number of factors which determine how far away a pilot can see another aircraft. Some of these factors are obvious and well known to pilots. Take size, for example. The larger the airplane the further away you can see it. Even more important is the amount of daylight. In dim light, such as we have at dawn and dusk, aircraft are hard to see. At night we must rely on external lighting to make aircraft visible. Against the blackness of night, external aircraft lights show up at a great distance and pretty well take care of the collision hazard. Against the brighter skies of dusk, dawn and daylight, however, external lights are much harder to see and are of little or no benefit for preventing collisions. Why aircraft visibility is increased by external lights at night, but not in the daytime will be explained later. Some other obvious factors which cut down aircraft visibility are glare from the sun, dirty windshields and canopies and windshield angle in relation to the line of sight.

Visual Acuity

Seeing an aircraft is basically a problem in visual acuity. For an aircraft to be visible, its angular size (visual angle) must exceed the threshold angle for visual acuity. In this case we are talking only about visual acuity for seeing a spot against a uniform background. We call this minimum visible acuity as opposed to minimum separable acuity (which applies to the minimum gap the eye can resolve). As a rough rule of thumb we say that the threshold visual angle is about one minute of arc. This means that a round spot must have an angular size of one minute at the eye in order to be visible. At one mile distance, one minute of arc is 1.5 feet. As is so often the case, we encounter some difficulties when we try to translate this rule of thumb into size and distance for visibility of an approaching aircraft.

Aircraft aren't nice round spots and the size and shape depend upon the angle from which you see them. But let's say we have an aircraft with a 10-foot fuselage cross section, coming head-on. If we ignore the wings and tail, which add very little to visibility when seen head-on, we come close to having a round spot. A 10-foot spot will give us a one-minute visual angle at about seven miles. Seven miles is about right for the maximum distance for spotting a small to medium size aircraft, such as a large fighter. For a large bomber viewed broadside, this distance may be more than doubled.

If we can see a fighter aircraft at seven miles, then why should we have a collision hazard under VFR conditions? The one minute of visual angle and seven-mile distance apply only when we have highly favorable conditions as follows:

- We have daylight lighting.
- The pilot's eyes are focused for distant vision.
- There is high brightness contrast between the aircraft and background (sky, clouds or earth).
- The pilot is looking directly at the other aircraft.

As we depart from the above conditions the threshold angle and visibility distance will change. Most changes will be in the direction of reduced visibility distance. Only conditions which increase contrast (such as glint from the sun and external lights at night) will increase the distance.

The need for daylight lighting conditions is obvious and well known. Visual acuity diminishes as the amount of light is reduced. At night we must rely on external lights to make aircraft visible.

Not so well known is the difficulty of the human eye in focusing for distant

vision when looking into the sky. To focus for the proper distance, the eye needs sharply defined objects to focus on, which are lacking in a clear sky. This focusing difficulty is usually called "altitude myopia," since it results in the pilot being focused for near vision when he should be focused for distant vision to see other aircraft. When this occurs, he will not detect aircraft at maximum distance even if all other conditions are favorable.

Contrast

Let us see how visual acuity and viewing distance are affected by contrast. The approximate relationships are shown in Figure 2. By contrast we mean the brightness difference between a target spot and the background against which the spot appears. Normally this difference is expressed as a percentage of the background brightness. If the spot is darker than the background the contrast cannot exceed 100 per cent, and has a negative sign.

If the spot is brighter than the background, the contrast is positive in direction and approaches infinity as a limit. As will be seen on the graph, our rule of thumb of one minute visual angle holds only when contrast is at the highest point.

As contrast approaches zero the threshold visual angle becomes very large. At zero contrast the threshold angle becomes infinitely large, and the visibility distance for a target of fixed diameter becomes zero. As shown in the illustration, the threshold visual angle becomes very small as high values of contrast are reached. In fact, the stars we see at night are effectively point sources, with no measurable visual angle.

Let's see now what kind of visual contrast values we can expect to meet when trying to see other aircraft for avoiding collisions. The background will either be earth, sky, clouds or haze, at or near the horizon. All of these may be relatively light or dark, depending on weather, time of day, azimuth angle and other factors. Likewise, the brightness of the threatening aircraft can change through a considerable range. Likely as not the other aircraft will appear as a dark spot against a lighter background of haze.

If lighted by the sun the other aircraft may instead appear lighter than the background. Sometimes glint from the sun will make the aircraft appear as a very bright spot, visible at great distance. The main point is that under some conditions the aircraft and the background will have very nearly the same brightness. This condition of low

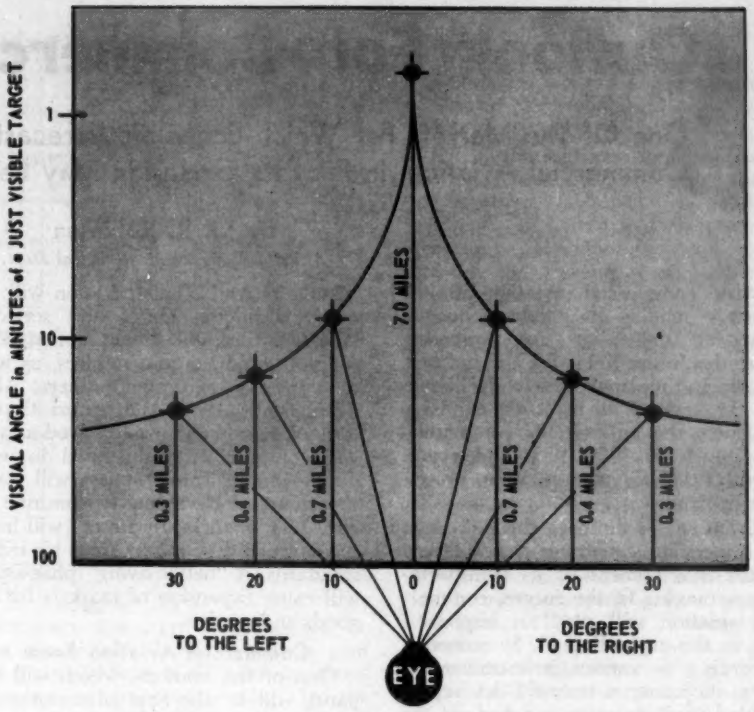


Fig. 3. The effect of offset viewing angle on detection distance for fighter size aircraft.

contrast means very low visibility distance. Under some combinations of lighting conditions the visibility distance will be less than the 1.16 miles required to give a seven-seconds warning at 600 miles per hour closing speed.

There is another characteristic of human vision which is probably even more important in relation to the collision hazard. This is the reduced visual acuity in the periphery of the eye. In fact our threshold visual angle of one minute holds only for a few degrees at the very center of our visual field. Go out only ten degrees from the center of vision and the threshold angle has gone up to about 10 minutes of arc. At 30 degrees out the threshold angle is way up to about 30 minutes. Even this value is for high contrast. For lower contrast values the visual acuity becomes even poorer.

Viewing Angle

From Figure 3 we can see that the pilot will pick up another aircraft at maximum distance only if he happens to look or fixate his eyes within a very few degrees of its position. In scanning the sky he may easily fail to look in the particular direction from which another aircraft is approaching. Each look or eye fixation normally takes about .5 second. At very high closing speeds this means a relatively few fixations between the time another plane could possibly be seen until it is too close to be avoided. It is easy to see that there is a considerable element of chance here as to whether a pilot will happen to look at the right place at the right time. Unless he does, another aircraft can sneak in close before he will see it. Even for very favorable contrast conditions the pilot must fixate within about five degrees of a target aircraft, of fighter size, to pick it up at our critical distance of 1.16 miles. The combined effects of low contrast and off center vision give us very poor visual acuity, to say the least.

From the foregoing, it is easy to see why a pilot's vision under VFR is not an adequate safeguard against mid-air collisions. Whether or not a pilot will see another aircraft in time to avoid it will depend on the particular light and contrast conditions and the way he scans the area ahead and to the sides.

From the information about human vision presented here, what suggestions can we make for reducing the collision hazard through pilot scanning techniques, aircraft exterior points, lights or similar means?

Assuming that a pilot is alert and watching for other aircraft, there is not

(Continued on Page 21)

Outlook For Commercial Aviation

One Of The Markets For Which Economic Forecasts Indicate An Expansion Is Commercial Aviation. In Fact Its Expansion May Be Greater Than Most Fields

By M. R. Robinson
ALPA Research and Statistical Dept.

With commercial aviation in the throes of one of its greatest changes, many air line pilots are wondering what the future holds for the industry in which they make their livelihood. On the basis of all presently available evidence, the outlook for commercial aviation from 1960-1975, and consequently the air line piloting profession, is good.

Today, as in the past, the growth of the American economy is closely linked to the development of its transportation networks. In the future, commercial aviation will play an important role in the expanding U. S. economy. According to various government reports, including a recent CAA report entitled *Civil Aviation and Federal Air Ways Forecast,* the years 1960-1970 will bring about expansion of not only the U. S. economy but also the field of commercial aviation.

Rapid Growth Seen

Leading business forecasters, government statisticians and economists forecast that within the next two decades a rapid population and economic growth will take place in the U. S. A. The post-war expansion of the U. S. economy has been phenomenal by pre-war comparisons. And this pattern, according to the "best of the business brains," will continue. Presently the Gross National Product (the best measure of the total market value of national output) is approximately $425 billion annually. Forecasts for 1960, 1965 and 1970 predict an annual level of $460 billion, $550 billion and $650 billion respectively. Expressed in another form, by 1960 the nation's economy will grow by 8 per cent; by 1965, 29 per cent; by 1970, 53 per cent. The 1960-1970 period has been labeled the "Golden Decade." The same forces which will cause the expansion of the nation's economy will, in turn, exert pressures causing the expansion of commercial aviation.

Just what are these forces?

Population and economic growth factors will be the basic expansionary forces in the years ahead.

Between now and 1970, over 40,000,000 Americans will be added to the population rolls. This addition will require additional goods and services. These, in turn, will create new markets for new products and services, as well as vitalizing existing products. Also, during this period, the historical pattern of increasing worker productivity will continue. And this, tied in with new technological advances, will cause the standard of living to continue to rise. The "man in the street" will have a continued desire to improve his living standards. A "better living" philosophy will cause expansion of markets for all goods and services.

Commercial Aviation Boom

One of the markets, which will expand, will be the field of commercial aviation. In fact, its expansion will probably be greater than most fields.

The purpose of this article is to briefly describe this expansion and its magnitude.

Some of the forces of the expansion have been building up for the last 10 years, and only recently have they become unleashed. Since World War II basic changes have taken place in the national economy:

- A great swelling in the U. S. population.
- Economic expansion beyond previous expectation.
- A sharp rise in personal income and in consumer spending patterns.

These factors will unleash the "tidal waves" that in the sixties will have its impact on the expansion of air transportation.

The population growth in the last decade has almost entirely been concentrated in major metropolitan areas from which 90 per cent of the air line traffic originates and terminates. With our population growth to continue, these major air transportation markets will increase by at least 45 per cent in 1970. In addition, it is expected the population in the metropolitan areas in the West and Southwest will grow more rapidly than the remainder of the nation, and this will provide a stimulus to additional traffic between these points and the highly populated cities of the East and Middle West.

The economic expansion of the post-war period has expanded many markets and created many new markets, all of which have added to our standard of living.

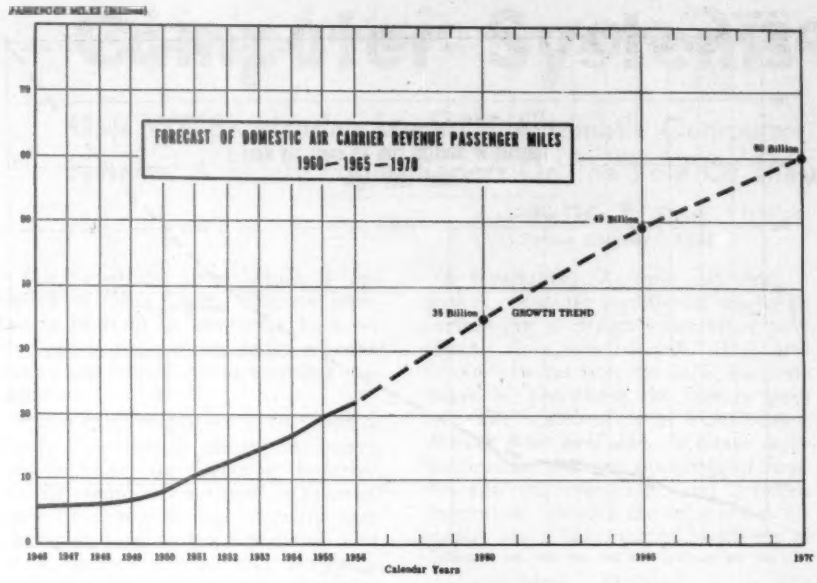
The sharp rise in income and spending during the last decade has brought about substantial changes in the spending pattern of the "man in the street." Today's typical American is spending more money each year on the so-called "luxury items." As income goes up, a larger proportion is spent for "luxuries" and a smaller proportion is spent for "basic necessities." Tracing the percent of personal income spent on transportation during the years of 1946-1955 bears out this point. Consumer expenditures for transportation has doubled while the rate for many of the basic necessities have been at a slower pace. This change of consumer spending habits, and the shift of families into higher income brackets will have a broadening effect on the size of the potential air travel market.

Inter-City Market

Before specifically dealing with the projections for air travel in the years ahead, air travel should be placed in its proper prospective. This can be done by briefly discussing the size and composition of the inter-city passenger travel market.

There are two segments of this market—private automobile travel, which represents 90 per cent of the total, and common-carrier travel (bus, rail, and air), which represents the remaining 10 per cent.

In recent years travel has expanded, primarily because of the increased number of autos on American highways. While surface common-carriers have lost ground, the commercial aviation field has made inroads into its competitors' markets. Actually, for the first time in history, air travel is now larger than either rail, coach or bus traffic. Since 1946, air travel, as a means of inter-city transportation, has shown a 400 per cent increase. It seems probable that air travel (in terms of passenger miles) will exceed total rail traffic within the next year or so, and, by 1970, it will account for more than two-thirds of the total common-



carrier traffic.

So far air line competition has been concentrated very largely in the long-haul portion of the common-carrier market. In trips of less than 250 miles, air travel is used in only 10 per cent of these trips. However, as the trip distances go up, the proportion moving by air travel rises sharply so that air lines are carrying 25 per cent of all passengers moving 251-500 miles, 44 per cent of those moving 501-1,000 miles, 66 per cent of those traveling 1,001-1,500 miles and 83 per cent of those traveling over 1,500 miles.

With this background in mind, what specifically is the outlook for air travel in 1960, 1965 and 1970?

During the past two decades air line passenger traffic has grown at a phenomenal rate. During the 1947-1955 period it increased 135 per cent, over 16 per cent annually and, as yet, there has been no real sign of slackening. If anything, it has gone up in 1955 and 1956. The trend is very likely to maintain its steady upward climb.

Impact Of Jets

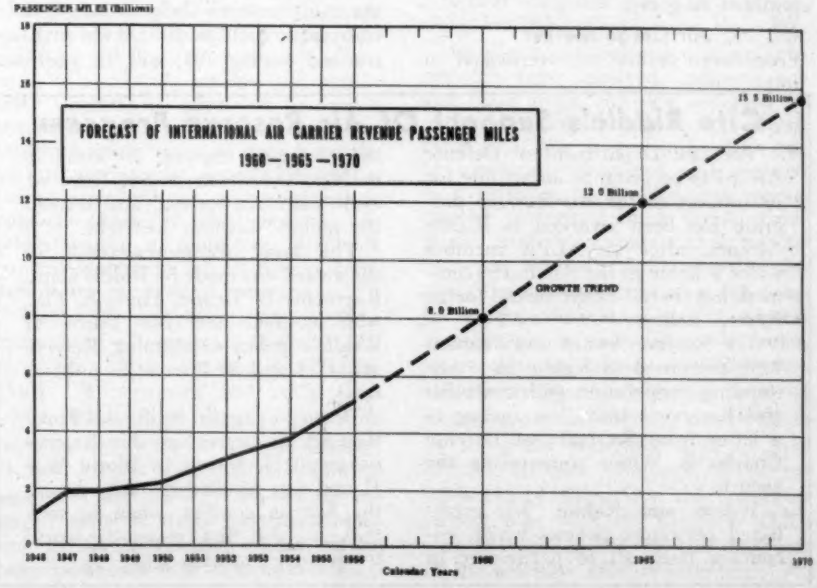
The advent of jets will usher in a new era of expansion which will make air lines the dominant public passenger carrier. Previously, the impact of the nation's expanding and prosperous economy was mentioned. "Leisurely living" is a new expression on the horizon of the American way of life. The shorter work week (presently and, certainly, in the future) has given people a feeling of leisurely and better living. Today, longer vacations are more commonplace than 20 years ago and this trend also will continue. This means that more and more vacations will be via air travel. People "want to and do get away from it all" with air travel playing an important role. In the future, air travel will capture more and more of such travel.

Despite air travel's past growth, surveys indicate that only a relatively small percentage of the total population has so far been drawn to air transportation. Since more and more people will become "converts" and with an expanding population, a huge and growing market potential for air travel looms in the years ahead. Americans are changing their habits and will continue to change, so that today's "non-flyers" will be converted to "flyers" in the years ahead. Continued safety and technological advances and improved scheduled dependability will widen public acceptance of air travel.

The newer features offered to passengers, such as air coach service and its lower rates, and turbo-prop and jet transports with its speed and comfort, generates new traffic. Jets will provide one-day or weekend round trip commuting service. Also more non-stop schedules will come about. The jet and turbo-prop aircraft will appreciably widen the speed and time advantages offered by air transportation as compared to surface carriers, particularly for long distance travel. In the short haul inter-city passenger market, the future is also optimistic. Helicopter operations offer vast possibilities for this type of operation. While the trend of helicopter traffic will continue upward, there will be no overnight change in air transportation's growth pattern. Acceptance is a slow and gradual process. It is expected that during the next decade this segment of air transportation will account for 5-7 per cent of the total air line passengers.

Specific Forecast

Specifically, the forecast is: that in 1960, 66 million passengers will fly 35 billion passenger miles; by 1965, 93 million passengers will travel 49 billion passenger miles; and, by 1970, 118 million passengers will travel 60 billion passenger miles. To achieve these figures, it means that an annual increase of approximately 12 per cent must take place up to 1960, approximately 7 per cent annually during the



1961-1965, and approximately 5 per cent annually during the 1960-1970 period.

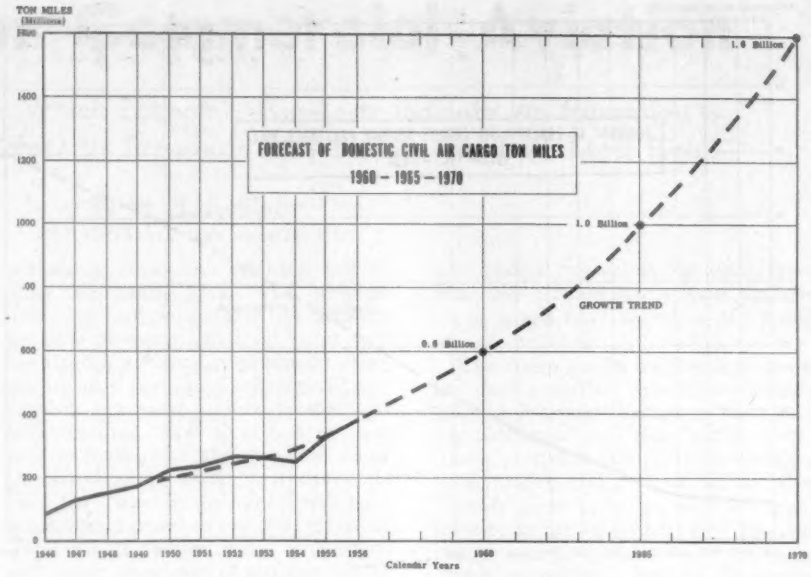
International Traffic

Up to this point, there has been no reference to international passenger service. Like its domestic counterpart, U. S. scheduled international and overseas air transportation has enjoyed a fabulous growth and there is no indication that this growth will slow down. Under the prosperous economic conditions which have prevailed since World War II, the demand for international transportation has grown each year. While our Gross National Product rose 37 per cent between 1947-1955, sea and air foreign travel increased 89 per cent. The pre-war international traveler utilized air transportation in only 4 per cent of the traffic. Presently, approximately 66 to 70 per cent of all persons going abroad are using air transportation. This trend will continue so that by 1970, it is a likelihood that 80 per cent of all international passengers will utilize air transportation.

Another factor to consider, when measuring the future of the international air market, is that up to the past year or two, relatively high air fares tended to limit foreign travel to the higher income groups. But with the steadily rising personal income, and introduction of air tourist rates, more foreign travel has been and will be encouraged. Not only is it pleasure travel that has expanded, but commercial and business travel has also expanded. Add to this travel by civilian government and military personnel and their dependents, and the demand continues to grow.

Air Cargo Market

Air cargo cannot be overlooked in the years ahead. Essentially air cargo has been a post-war development since air freight service was not generally available prior to the war. The benefits shown during World War II of air cargo gave the impetus needed for this segment to grow each year so that since World War II air cargo has increased by over 400 per cent. However, it still falls behind the potential market that some observers feel it should have. In the years to come much can be expected for the air cargo segment of the market since it has overcome some of the inherent difficulties of any new venture. Lower rates have been brought about by more efficient and larger capacity equipment. Even new passenger equipment will help air cargo, since equipment such as the Lockheed Electra and Boeing 707, will, in addition, to their normal passenger load, carry 2 tons and 4½ tons of cargo respectively. This means that little, if any, additional cost is involved in the transporting of such cargo and that frequent passenger schedules will help supplement service to fringe or outlying areas. Air cargo will also benefit from rising public acceptance as shippers become increasingly aware of the speed and indirect cost savings resulting from the use of air cargo. While long established shipping practices will change through a slow but gradual process, the utilization of air cargo will depend to a great deal on the vigor with which the air carriers attempt to develop the vast market. It is estimated that by 1960 this market will increase by 58 per cent, by 1965 by 163 per cent, and by 1970, it should be about 320 per cent greater than today.



From almost any viewpoint it is a reasonable and logical prediction that the field of commercial aviation in the immediate years ahead will grow and probably to an extent greater than most of us realize. Air passenger travel (both domestic and international) has a bright and prosperous outlook. Air cargo has become an established industry and it is no longer in an infancy stage. While it is realized that many problems must be resolved and that pilot employment growth and promotional opportunities are not by any means a parallel projection of business increases because of the impact of aircraft of greater speeds and capacity, nevertheless, pilots and the nation as a whole will derive additional benefits from this dynamic growing industry.

Cite Riddle's Support Of Air Reserve Program

The first Department of Defense Award to be given to an air line for its support of the Air Reserve program has been awarded to Riddle Airlines, after an ALPA member wrote a letter to the Air Force commending the all-cargo airline for its Reserve policy.

The Reserve Award and Pennant were presented to Riddle for "outstanding cooperation with reservists and Reserve activity," according to a letter from Secretary of Defense Charles E. Wilson announcing the award.

Wilson said Riddle "has established personnel policies which encourage reservists to participate in the military training so vital to building the strong reserve force we must maintain today," and termed the policy "patriotic foresight."

The basic recommendation for the award was made by Riddle Capt. Raymond E. Deane, Hialeah, Fla., who notified the Air Force of Riddle's policy concerning Reserve activities and its interest in military matters.

Deane, a captain in the Air Force Reserve, is active in the Reserve program. He served in World War II and was recalled for duty during the Korean conflict, when he took part in the first round-the-world troop carrier mission.

Computer Systems For ATC

Pilots Will Be Hearing Much Of Automatic Computers In The Air Traffic Control Systems. A Safety Forum Report On The Role Of These Electronic Brains In ATC

By Dan C. Ross
Senior Engineer, IBM

The viewpoint from which I approach the Air Traffic Control problem is that of an electronic engineer involved in the systems design of computers and related data-processing machines.

Electronic computers of one sort or another are already playing an important role in the aviation industry. Analog computers are used as essential parts of autopilot and stability augmentation equipments, navigation aids, cruise control devices, and automatic landing systems. Small special-purpose digital computers are being developed, which will bring together in one airborne unit all of the computing and control functions required for the complete flight profile.

This article will be concerned with the large-scale digital computer which is serving the aviation industry now as an important tool for both the engineer and the accountant and will serve the aviation industry in the future as the central element of the air traffic control system of the United States.

Computers' Growth

Ten years ago, the high-speed digital computer was little more than a scientific curiosity; today, such computers are being employed on a broad basis in almost every industry. The rapid growth in the number of applications in which computers are performing essential services can be attributed to the following characteristics of the modern electronic data-processing machine:

▸ **High Data-Processing Speed.** Existing machines can operate at speeds of the order of one hundred thousand additions per second and machines now in development will operate over ten times as fast.

▸ **Large Memory Capacity.** The high-speed internal memory of a modern data-processing machine can store a few hundred thousand alphabetic or numerical symbols. This large amount of data storage can be further supplemented by slower memory devices such as magnetic discs, drums, or tapes, with capacities of hundreds of millions of symbols in a typical installation.

▸ **Flexibility.** At one moment, a typical computer installation might be performing a design calculation pertaining to a new aircraft wing, and fifteen minutes later the same machine might be processing the factory payroll. The wide variety of input-output devices now available, facilitate communication between operating personnel and the computer, and between computers, whether the separations involved are a few feet or hundreds of miles.

▸ **Reliability.** Contrary to earlier predictions by various prophets of electronic doom, even the most extensive of the computing systems now in existence exhibit very low frequencies of error and failure. Techniques are available which permit the computer engineer to design a machine to have a reliability performance as near perfect as can be reasonably required.

Real-Time Control Systems

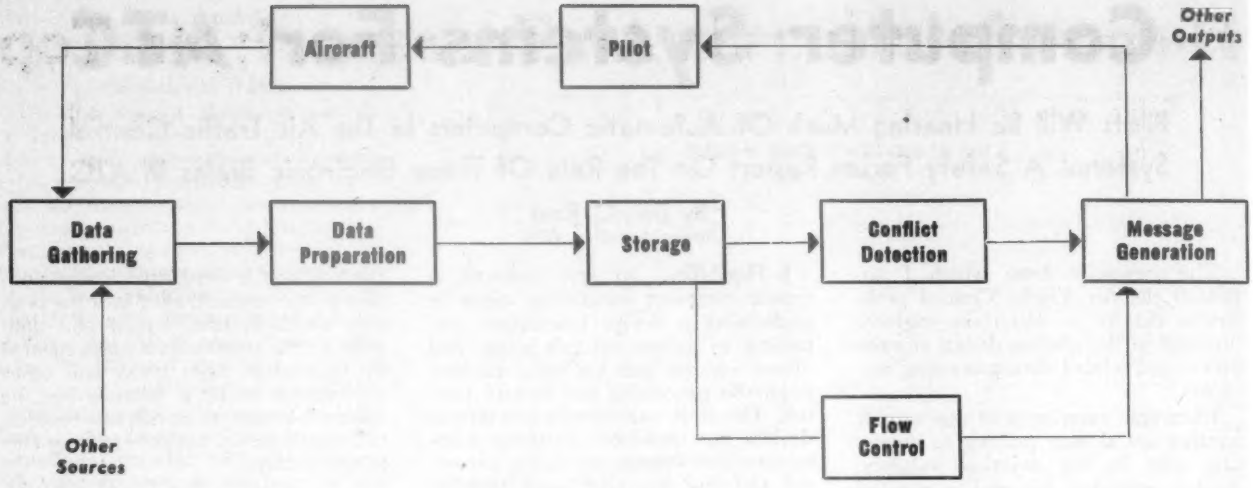
High-speed computing techniques have been successfully applied to all but the most abstruse problems in the fields of physical science, engineering, and commerce. The next large application area, in which computer system designers are already working, is that of real-time control systems. In such systems, a high-speed computer, located at the logical center of a network of automatic sensors and actuators, divides its attention in rapid sequence among the functions of accepting various types of data from the sensors, performing appropriate calculations and decisions, and transmitting control signals to the actuators—in other words, a multi-loop feedback control system in which digital computers are the central elements.

The ATC complex is an excellent example of a large-scale feedback system. The sensor elements in ATC include the personnel and equipments which handle flight plans and position reports, the computing and decision element are the CAA controllers at the control centers and towers, and the actuator element is the communication link to the airframe involving, again, both personnel and equipment. Each control loop is completed in the position of one aircraft, since it is the position which is both sensed and controlled. The position data supplemented by up-to-date flight plans and other information make it possible for the control element to anticipate conflicts sufficiently far in advance to take corrective action.

Performance Details

A digital computer performs any task assigned to it by executing a relatively long sequence of relatively simple operations. The standard analogy involves a storage cabinet having numbered compartments, an ordinary desk calculator, and an operator. The operator starts by obtaining the first instruction from compartment No. 1, executing this instruction, and then proceeding to compartment No. 2 for the next instruction. An exception in the sequential process of referring to the storage compartments occurs in the execution of a "branch" or "transfer" instruction. Such an instruction allows the computer to make a choice as to which routine to execute next depending upon the result obtained from the previous sequence of instructions. Other instructions in the repertoire of a typical computer are: add, subtract, clear, multiply, divide, store, shift, etc.

An electronic computer is able to perform very involved computations and make quite complex decisions by performing simple operations at a very rapid rate. Any control task which can be specifically described and reduced to a program of detailed instructions can be performed on a digital computer. And it turns out that practically any control task fits this description. The labor of producing the computer program will, of course, depend upon the complexity of the function which the program is to perform. Significant savings in the effort required to produce such programs can be made by using the computer itself to help prepare its own programs. However, it should be noted that the computer cannot cope with any situation which was not anticipated by the designers of the machine and its program.



Functional Block Diagram Of The Air Traffic Control System

It would appear that an ATC system in the future will involve both automatic equipment and human operators. The preceding statement is true, regardless of whether the system normally operates in a completely automatic way or whether it normally employs some manual functions—the latter being the more likely. It should be noted that the automatic parts of the system deal entirely in terms of numbers and symbols, not with their meanings—almost the exact reverse of human behavior. A computer cannot care less whether the numbers it is juggling at any given moment pertain to such concepts as "airways" or "areas," "fixed blocks" or "moving blocks," "positive control" or "permissive control." Furthermore, the computer cares little whether the position coordinates refer to a local rho-theta or to a generalized longitude-latitude system. Most of these latter points of philosophy are injected into system design to meet the requirements, real or imagined, of people, not of machines. It is not too surprising, then, to find that the most difficult problems in the design of a semi-automatic ATC system stem from the requirement that men and machine must work together.

Requirements For ATC Function

How big are the computers and how many computers are required to perform the ATC function? Some of the factors which have no important connection with this question have been discussed earlier. Factors which are of real significance include the following:

- Which of the required system functions are to be performed automatically and which are to be handled manually? Some of the required functions are: storage of flight plans, gathering of position data, comparing aircraft positions with flight plans, prediction of potential conflicts, resolution of conflicts, transmission of clearance data to aircraft, flow control, etc.
- What is the maximum number of aircraft aloft at one instant which the system must accommodate? How are these aircraft divided into major control areas, and what are the boundaries of these areas?
- How many different types of input data must the computer accept, and what is the maximum data rate anticipated for each type? How many different types of output signals must the computer generate, and what is the maximum data rate required for each type?
- How precise and how accurate is the input data, and what precision and accuracy is required in the output signals.
- Is each input message identified or is a large amount of sorting and correlating of input data required? How much extraneous noise is included in the input data?
- How many human operators are to cooperate with the machine, and how much data does each operator transfer to and from the machine?
- Where is the line to be drawn between expected situations which the machine is prepared to handle and other situations for which it is not prepared?

Quality Of Input

The question concerning the quality of the input data is quite important as far as effect on computer size and capacity is concerned. If each message obtained from some automatic position telemetering system includes identity of the aircraft concerned, then there is very little difficulty in using this data in the computer. This is particularly true if the amount of noise and interference contained in the input signals is very small. If the input data is not identified and includes an appreciable percentage of spurious responses, then the complexity of the computer required is many times greater.

Preliminary studies of a fairly broad spectrum of possible answers to the questions listed above indicate that it is quite practical to evolve an ATC system in which digital computers will play important roles. Detailed answers to these questions are needed before one can design the system and state its cost.

Essential Elements

The most important elements of the ATC system to automate, on the basis of obtaining a large percentage of the eventual benefits for a small percentage of the eventual cost, are as follows:

- Automatic determination and storage of identified fine-grain position data.
- Automatic reception and storage of flight plan data.
- Automatic preparation of displays for use by the controller.
- Automatic aids to inter-controller and inter-facility coordination.

The automation steps listed above are considered to be mandatory. Several additional steps, which are considered to be justified by the system re-

(Continued on Page 22)

Human Relations In Air Transport; Mr. Top

Who Sets The Tone Of An Air Line? Why, Mr. Top. His Thinking Is Evident All Along The Line. After Reading This, You May Be Able To Categorize Your Mr. Top

By Capt. William Karraker
PAA

At first blush it may seem the height of folly for me to write on the subject of air line presidents when I "know" nary a one; that is, to shake hands and pass the time of day with. But a biblical phrase is apropos, "By their fruits shall ye know them." Each Mr. Top sets a tone for his air line which is unmistakable throughout his enterprise and visible at every traffic counter. Presidential leadership is the keystone of every air line organization. Not only does Mr. Top set the overall goals of organizational activity, but his behavior and attitudes affect the most remote details of such activity.

It will be my purpose to describe the air line president group in terms of what the social scientists call models. I shall label the two models I shall use, "Effective" and "Ineffective." But I hope that you will consider these only as segments of a spectrum. An actual "effective" may very well be doing a bang-up job with an air line that is barely making ends meet. An actual "ineffective" may be the primary cause for another air line's failing to show a greater "profit" than it does. Roethlisberger[1] applies the term "frozenness" to the "leader" who is such a blight upon the enterprise he leads. Such an air line may show a profit, but, because of the "frozenness" of its leader, may not be the successful enterprise it could be with a different Mr. Top

Defining 'Leadership'

J. A. C. Brown,[2] struggling to define "leadership," concludes that, "The word makes sense only when we specify to what end and in what circumstances the leader will be expected to act," and ". . . what makes for good leadership in one situation may actually militate against it in another." Perhaps it is better to avoid the confining effects of a definition, and to construct the promised models as targets for criticism, and as outlines for "case history" treatment at another time.

Mr. "Effective" Top is, above all else, a man who is concerned with the people who work with him on his air line. While he may picture himself as the apex of an organizational chart that resembles a pyramid, he is the first to recognize that the apex would not exist as such without the base. Consequently he is deeply concerned with the well-being of the whole pyramid, and not just a segment of it.

He is more interested in hiring, placement, training, and personnel management procedures than in firing and disciplinary tactics, recognizing the latter as indications of shortcomings of the former. In setting the tone for dealing with subordinates he emphasizes situations rather than traits. He tends more to look for ability in his organization not being used and to arrange to use it, than for human resources which can be sloughed off because they are not presently being fully employed.

He recognizes the paramount effect of his organization's communications system, formal and informal. As Stuart Chase has written,[3] "The Modern Executive lives in an increasingly complicated network of communication, with lines leading up, down, and sideways from his desk." Mr. Effective Top finds use for the sturdy new science of Semantics, the "systematic study of meaning." He goes behind the dictaphones, the electric typewriters, the duplicators, and the presses in an effort to arrive at valid meanings to gain background for informed action. He recognizes that bales of money spent on every type of communication device will all be wasted, if his organization fails to hire articulate employees, and fails to employ good semantic principles. What those principles are will be treated at another time.

Executives' Peculiar Traits

Mr. Effective Top does not reckon his position and power by the quantity of exclusive information about the air line he holds. Mason Haire[4] describes one of the peculiar traits of some executives, that of hoarding information. Conversely, our man says to his subordinates, clear down to the base of the pyramid, "All the information I have, you will receive."

He values "feedback," the so-called "upward" flow of communication. On the writer's air line this is accomplished by having some non-management pilots in attendance at each monthly management staff meeting. Those pilots "feed back" information from the line, raw material for improved executive decisions.

Mr. Effective Top does not tie himself down with too much detail, but relies heavily upon staff men and consultants. While his eyes continually sweep the "forest" his assistants label, measure, prune, fertilize, or cut the trees. He realizes that too much attention to detail on his own part will so fill his day that the broad decisions and actions required by his job will not be accomplished.

He conducts personal, periodic job reviews of these assistants and specialists, and of those members of his organization reporting directly to him. The dilemma of Charley Gray and Roger Blakesley in Marquand's *Point Of No Return* is the classic literary example of the anxieties and political shennanigans brought about by a Mr. Top who didn't tell his people clearly and frequently "how they were doing." Periodic job review is a boss' best tool. It is rarely used—as far as I can determine—in any air line organization. Pilots have route and proficiency checks on isolated flights, but no job reviews, no critique on their day-to-day performances. Other air line employees do not fare even as well as pilots.

A System

Mr. Effective Top sets up a system of rewards and punishments that is at once fair and effective. He tailors the principles of the system to fit the needs of his particular organization. He gains cooperation from his employees' unions to form and administer the system, and he makes sure that no employee is in ignorance of the system. In this regard, he recognizes the futility of a code, neatly printed in a pamphlet, and he uses all the facets of his communications systems, formal and informal, to spread the "word."

Above all Mr. Effective Top, deeply interested in his people, is a teacher and a teacher of teachers. He exercises all the communication arts to teach the why, how, and when of all the jobs

The ALPA Camera

Helicopter Discussions

ALPA representatives studying helicopter operational and airworthiness problems at Home Office, in late May. L. to r., standing: H. Cates (CHA), C. F. Eck, ALPA Engineering and Air Safety Dept.; seated: F. Schrott (NYA), C. E. Cochran (OZA).

Air ne Vete

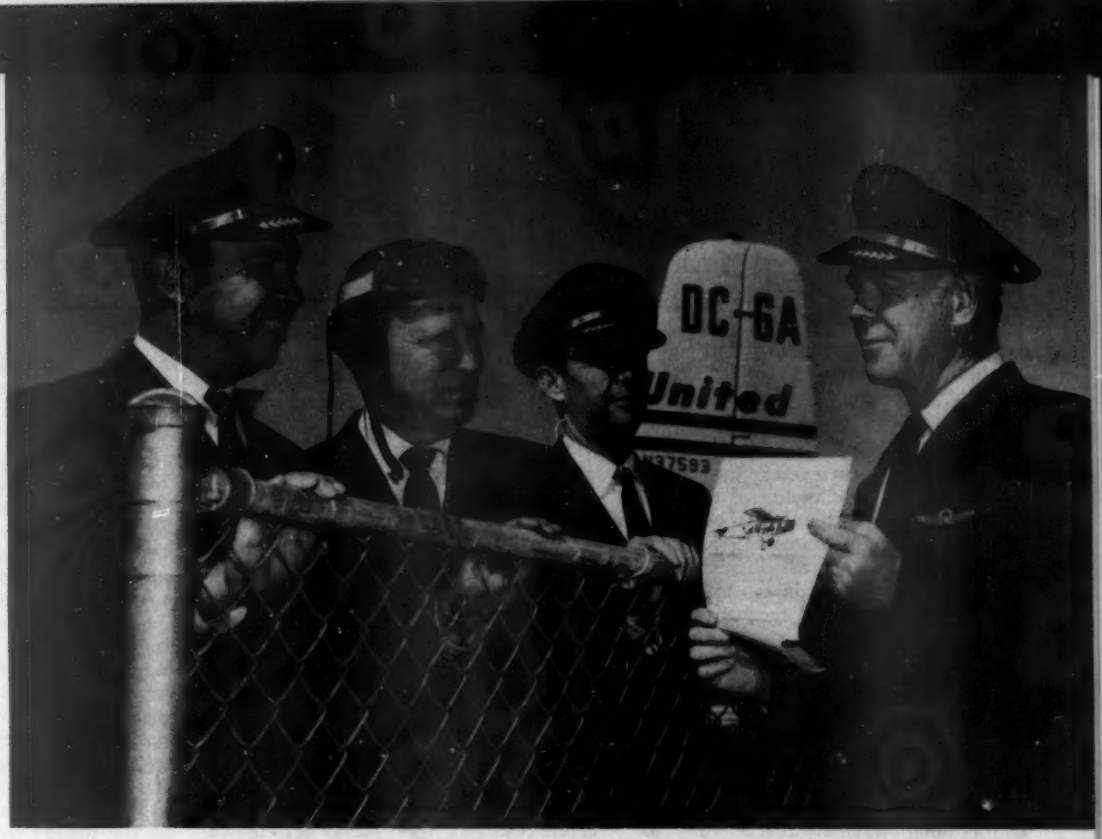
A century of commercial avi sented by the four UA gathered in San Francisco silver anniversary celebra picture of Boeing 80, in u began their careers 25 years Richard Thornton. Others t Captains Floyd Davidson, A Stainback, and Clarence Sa based at San Francisco.

ALPA Lauds USA

ALPA recently commended the courageous rescue operations of USAF personnel during a CAP DC-4 landing accident at Greater Pittsburgh Airport, April 18. (Fire damage on left wing is shown in picture.) AF personnel battled the severe fire while the plane still rolled down the runway, entering the flaming area several times in the course of extinguishing the blaze. The fire-fighting trucks took part in the operations.

ALPA

era



Air Line Veterans

y of commercial aviation is repre-
by the four UAL pilots who
in San Francisco recently for a
nniversary celebration. Holding
of Boeing 80, in use when they
eir careers 25 years ago, is Capt.
Thornton. Others from left are:
Floyd Davidson, Albert (Pinky)
k, and Clarence Savage. All are
San Francisco.

New MEC's

Two more new MEC's met in organizational meetings at the Home Office during recent weeks to become familiarized with the Association's policies, programs and staff. On right: the FTL MEC; below: the NWA MEC.

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Dr. Warner Leaves ICAO Council

Dr. Edward P. Warner, a former member of the Civil Aeronautics Board, recently retired as President of the ICAO Council after more than eleven years of service. He is being succeeded by Walter Binaghi of Argentina.

One of the founders of ICAO, Dr. Warner attended the initial meeting of the Council of the Provisional International Civil Aviation Organization in August, 1945, where he was elected as President of ICAO's executive body, to be re-elected to this office ever since.

During his term of office, ICAO has grown from 26 member states to 70, which now cooperate within the framework of this United Nations specialized agency. Guided by the Council, it has produced standards which have been adopted throughout the greater part of the world for such navigational devices as metereology, air traffic control and communications, and for regulations defining the rules of the air, the conditions under which aircraft and personnel are to be licensed and aircraft to be operated under regular air transport service, and for the facilitation of aeronautics through the simplification and standardization of customs and immigration procedures.

ALPA, as a member of the International Federation of Air Line Pilots Associations, is represented in ICAO at the international level. IFALPA's status with ICAO is that of technical advisors and observers. ALPA itself has had on occasions the same status in the U. S. delegation to ICAO.

Develops Global Navigation

Dr. Warner, as President of the ICAO Council, has participated in regional meetings in most of the countries cooperating through this international organization to help prepare detailed plans for the placing and operation of air navigation devices.

During recent months, Dr. Warner also headed the "ICAO Jet Age Task Force," a special implementation panel composed of international experts, set up by the Tenth Session of the ICAO General Assembly. Its purpose is to survey the special problems of the North Atlantic, European and African, South American and Caribbean regions.

that must be done if his enterprise is to succeed. He teaches with a free and effective flow of information, and not with a "learn, you S.O.B., or I'll fire you" attitude. He checks his own "transmitter" before assuming that a subordinate's "receiver" needs repair.

Does this model give us a picture of a perfect air line president? Substantially, yes. Such a fellow will be outstanding, and his enterprise will probably be as successful as its economic environment will permit. He will doubtless get maximum cooperation from his employees, and get along with governmental agencies, and his customers, but he may be a casualty in competition with a group of rivals, most of whom are totally lacking in scruples or ethics. His enterprise may not "succeed," but he will certainly not be "frozen," and given time he will add "success" to his trophies of "employee loyalty," "customer good will," and "industry respect."

Mr. Ineffective Top is not simply the antithesis of Mr. Effective. What I write of him is set out in a spirit of what is hopefully labeled "sympathetic understanding." Such suffering as he metes out to subordinates, and however troublesome he is in his dealings with unions, governmental agencies, and even some of his customers are trifling compared to his own torture and frustration, usually evidenced by alcoholism, ulcers, or early heart failure.

Where Does He Come From?

Where does such a man come from in the Air Transport Industry? I suggested in my previous article on *Human Relationships in Air Transport* that some understanding of executives could be achieved by exploring the diverse characteristics of "promoters" and "operators." I think it can be shown that a "promoter" president (Grant LeRoux calls him a "founding father") who cannot make the change from "promoter" to "operator" as his air line ceases to be a promotion and becomes an operation, becomes in direct ratio an ineffective rather than an effective Mr. Top. What are the indications that we have a Mr. Ineffective Top on our hands?

S. I. Hayakawa[5] tells us where he comes from and what his characteristics are, and I shall try to indicate how retention of those characteristics after "promotion" is over and "operation" is under way make a Mr. Ineffective Top.

Hayakawa points out, "Success in a marginal business requires one or more of the following: (1) finding an undeveloped market that established businesses have ignored or overlooked; (2) having the foresight (or luck) to get into a type of business that is not profitable now, but eventually will be; (3) being sufficiently aggressive, skillful, and shrewd in business to survive even under the most unfavorable conditions; (4) being willing to work twice as hard as the next man." Marginal business men, says Hayakawa, show such characteristics as "(1) a single-minded absorption with making money, preferably the quickest way; (2) extreme aggressiveness and shrewdness, and an unwillingness to pay high wages; (3) a tendency to be somewhat overproud of the money they have made; (4) a tendency to adhere firmly to the principle that 'business is business'—in other words, a willingness to sacrifice considerations of sentiment or humanitarianism or even ethics if necessary in the interests of profit."

Our young air transport industry began totally as a collection of "marginal businesses." Every enterprise in the business was high-cost and low-yield. Let's admit that government subsidy was the lifeblood of this newborn industry. At the top of each such enterprise was a "promoter," a "marginal businessman," and credit is due to each of them who gradually reduced the need of his company for governmental subsidy. In the face of ruthless rivals, and a lethargic group of potential customers only the aggressive, hard-driving Mr. Top survived. Are aggressiveness and all the other characteristics of the "marginal businessman" appropriate in the air transport industry today?

A 'Promoter'

Mr. Ineffective Top is essentially a "promoter" who has been unable to become an "operator." During his promotional activity, turnover and absenteeism in his enterprise were appalling. Generally, he gathered "romantics" as employees who were chiefly motivated by the "romance of the air," but to whom disillusion came swiftly in the face of low wages and poor working conditions. An exception was the pilot group which stayed on chiefly because of accrued seniority,

relatively good wages, and acceptable working conditions, all of which were "fought for" by Dave Behncke and the then officers of ALPA, who themselves were "promoters" and "marginal businessmen" through and through.

Mr. Ineffective Top carries over habits of action which are no longer appropriate in the industry. He remains autocratic, uncommunicative, and emotional.

He tends, primarily, to look upon himself as "owner of a property," even though his shares of stock in the airline he heads, are a tiny fraction of the whole. He has watched "his baby" grow, giving it "the best years of his life." He's picked his managers carefully, usually personally, and if they can't get the work out he'll find other managers who can. Mr. "Ineffective" Top spends millions on aeronautical research and purchase of new aircraft, but the budget of his Personnel Manager is limited to the bare essentials necessary to keep records and to do battle with "those damned unions" in reluctant collective bargaining. Mr. Ineffective Top is thrilled at the sight of a shiny new aircraft or a multi-million-dollar hangar. He tends to be disgusted with the cost involved in hiring the best available new employees. He finds it less painful to hire "efficiency experts" who show him how to reduce his employee roster, rather than to employ "human relations" or "group dynamics" specialists who try to show him how to improve safety, customer service and efficiency; and, at the same time, increase employee satisfactions.

When a shortcoming of an employee is reported to him his immediate reaction is, "Fire the guy!" not "I wonder what happened, why it happened, and how we can best keep it from happening again." In other words, he tends to hire another person (with no careful hiring policy in operation), place that person by summary assignment in the job left vacant by the equally-summary discharge (disregarding currently valid techniques for placement), apply the same managerial practices to the new victim, and then wonder why the whole process is repeated.

A Success?

Why is Mr. Ineffective Top frequently thought to be a "success" because his air line operates at a profit? No one considers how much greater that profit would be if he functioned effectively. Only a consultant in human relations, that science which blends, among others, anthropology, sociology, psychology, logic, and semantics, can possibly analyze the human element of the air line—from Mr. Top to the lowest echelons—and make suggestions for improvement. History records the salutary effects of such suggestions on production and profit. The classic case is the work of Elton Mayo at Western Electric[6]. Walker, Guest and Turner made recommendations to certain automobile manufacturers which measurably increased production and concomitantly improved employee satisfaction[7]. Gardner, Harrison, and Kahn have succeeded in assisting two major air lines[8]. And, after a Mr. Effective Top had operated successfully for some years at Jersey Standard, Stuart Chase was consulted to find out how he had done it[9].

If you find yourself working for an air line headed by Mr. Effective Top, rejoice! If not, there is much you, as a pilot, can do. For one thing, meeting hostility from "above" with hostility of your own will help no one. ALPA's President Sayen best sets the tone for us when he insists that pilot-management disagreements represent mutual problems more than anything else. It's like keeping the eye on the ball in tennis, instead of upon one's opponent. Keeping the attention on the mutual problems created by the context of Mr. Ineffective Top, his "promotion" that has become an "operation" no longer his, and his unsatisfied employees and customers, is probably the only useful course of action.

Open warfare is a dull and useless business. Mutual aid is the very essence of our being human beings. Mr. Ineffective Top is more to be pitied than scorned. He may even be educated by his pilots or other employees.

FOOTNOTES TO THIS ARTICLE

1. Foreword by F. J. Roethlisberger to *Worker Satisfaction and Development* by A. Zeleznik, Harvard Business School, Division of Research, Soldiers Field, Boston 63, Mass. 1956. $2.00.

2. *The Social Psychology of Industry*, J. A. C. Brown, Pelican A 296, p. 219.

3. *Executive Communications: Breaking the Semantic Barrier* by Stuart Chase, The Management Review. Amer. Management Association, Inc., 1515 Broadway, New York 36, N. Y. $1.00.

4. *Psychology in Management* by Mason Haire, p. 31: "Another common phenomenon occurs when supervisors at all levels of the management hierarchy heard information and tell their subordinates 'only what they need to know.' To do this greatly increases the ego-aggrandizement of the superior. It is the hallmark of the superior that he knows more of the overall picture than the man lower down. Consequently, to hold back information shores up and makes more secure the superior's superiority. It may hamper the subordinate's work either directly in his lack of information, or indirectly in his lack of feeling that he has an over-all grasp of what he is doing and that he is in the confidence of management. But it does pay rewards to the superior when he can say, with a knowing look, 'Well, we've got some big plans that you don't need to worry about. You just turn out the widgets and we'll take care of the rest of it.' We only need to question whether it is worth it to the company to have him feel that way."

   AUTHOR'S NOTE: *It is interesting to reflect that a pilot, writing to me on the general subject of Human Relationships in our Industry, touched on this very problem: "I was attending an MEC meeting . . . and on the last day of the meeting we had invited several company officials to have dinner with us, one of whom was J—— F——, at that time V. P. in charge of Industrial Relations . . . I found myself in conversation with Mr. F—— along the lines of 'How about some of you Chiefs letting us braves in on what goes on in this air line once in a while?' It was a friendly conversation, but short, and I was told, in a nice way, to just go back to . . . climb into the right seat of that little old DC-4, fly my trips and quit worrying about management's problems . . . there were plenty of people . . . who were paid to worry about that particular problem."*

5. *Language in Thought and Action* by S. I. Hayakawa, Harcourt, Brace & Company. Inc., New York. AUTHOR'S NOTE: *Dr. Hayakawa teaches a stimulating course in the Arts and Sciences of Communication by correspondence with the Home Study Dept. of the University of Chicago, Chicago 37, Illinois.*

6. Roethlisberger, F. J. and W. J. Dickson, *Management and the Worker*, Cambridge, Mass.: Harvard University Press, 1939.

7. *The Foreman on the Assembly Line* by Charles R. Walker, Robert H. Guest, Arthur N. Turner. Institute of Human Relations, Yale University, Harvard University Press, Cambridge, Massachusetts, 1956.

8. (Inferred from your correspondence re United and American. May I have citation to published material?) Note to Mr. Kahn.

9. *A Generation of Industrial Peace* by Stuart Chase, Standard Oil Company of New Jersey, 1946.

Performance Requirements For Transports

More Than Finite Values In A Manual Of Compromises, They Must Exceed The Minimum Needs For Safe, Successful Flight Under The Conditions Encountered

By Capt. L. H. Mouden, BNF

Chairman, ALPA Airworthiness and Performance Study Committee

What are the performance requirements of a commercial transport airplane?

Some contend that these are set down in part 4.b of the Civil Air Regulation. These regulations give finite values and specific formulas which are used in determining certain minimum performance requirements. There may be disagreement as to the correctness of the specific value used in certain portions of the regulations or as to the necessity for a certain specified requirement; but we must agree that under the regulations, and particularly under part 4.b, the United States has produced and flown the safest aircraft in the world. The air line pilots are not convinced, however, that the regulations are adequate in all respects, or that the performance obtained from some airplanes under certain conditions provides an acceptable level of safety. All segments of the industry must continue to work together in establishing performance datum lines, based upon the previous history and the technical knowledge available, which will produce an acceptable minimum level of performance.

A review of the yardstick for measuring performance requirements in various configurations of flight, as specified in parts 4.b, 40 and 41 of the Civil Air Regulations, was initiated over a year ago by the Bureau of Safety Regulations of the Civil Aeronautics Board, has been under consideration by the various segments of the industry, and will receive another public hearing in the very near future.

The part of 4.b specifically under consideration deals with the Performance section. This represents a tremendous amount of work by those who drafted the proposals, and they deserve much more commendation and less condemnation than they undoubtedly will receive. While we may not agree with all the values used in the proposal, we believe that it is a progressive and constructive step, and one that merits the cooperation of the entire industry in its eventual solution.

Cites Many Facets

After several years of evaluating pilots' comments, working with various segments of the aviation industry, and participating in the investigation and analysis of air line accidents, the pilots of the Air Line Pilots Association are convinced that there are many facets to performance requirements besides those spelled out in paragraphs 110 through 125 of part 4.b of the Civil Air Regulations. The men flying these transports long ago realized that the regulations did not cover all the performance requirements that the public presumed to be an inherent part of making air line travel safe.

To the pilot occupying the cockpit of a particular transport airplane, the performance of that airplane is at all times very real and vital to him. He does not think of it in terms of the finite values in a manual that were achieved as the result of engineering compromises with economics. He thinks in terms of the airplane's ability to clear the obstacle ahead, stop on the remaining runway, or reach that emergency field when the second power plant has failed. If anyone, while occupying that seat as a pilot in command, were asked to define the "performance requirements" of that particular airplane, we would obtain many different definitions.

Principles Of Requirements

When all the technical aspects of any definition had been eliminated, it is quite probable that there would be rather uniform agreement as to performance requirements. The air line pilot believes that *the basic performance requirement of any aircraft is that it have the ability to exceed the minimum requirements for safe, successful flight under the conditions encountered.*

The interpretation of *safe* and *successful* must also be applied to conditions encountered, which might result from unsuccessful completion of the flight to its destination. There is no question but that such a definition imposes a tremendous responsibility on the manufacturer, the designer, and the engineer as well as on the operator and the pilots themselves. Anything less could not be acceptable by either the pilots, the manufacturer, the operator, or the public. I must emphasize the pilot's firm belief that there is common agreement on this as a goal, and that the possible areas of disagreement as to whether such conditions of a definition can be, or have been, met would be the basis for discussion of a subject such as we are now considering.

Some areas of possible disagreement have been or can be eliminated by demonstration of the airplane's ability to meet specified performance requirements under the conditions it encounters in scheduled operation. In other cases, it is obviously necessary to accept common sense evaluation based on practical previous experience in determining whether specific performance requirements can be met. For example, in considering the ability of an aircraft to ditch, it would be inconceivable to expect to ditch a $5 million jet transport to prove that it was capable of doing it successfully.

Let's give further consideration to the pilot's definition of performance requirements relative to the airplane's ability to provide safe, successful flight under any conditions which might be encountered. This prescribes that safe, successful flight conditions must come by three means:

- By being able to cope with the environmental conditions which present themselves;
- By providing for any performance deterioration condition which results from an inherent part of the aircraft or its power plant, and
- By utilizing a sufficiently simplified and concise means of overcoming performance deficiencies as to permit the flight crew to cope with the condition in a manner to prevent it from becoming catastrophic.

Overcoming Environment

Environment starts with the ground and includes all encounterable conditions to the maximum, emergency flight altitude. While we recognize that this

is a different concept, from the engineering standpoint, than is normally associated with performance requirements, we would like to expand this to show why we feel that it is an inherent part of the performance requirement itself.

Some of the environmental factors which affect performance are temperature, humidity, wind, ceiling, visibility, runway length and altitude, obstructions, and atmospheric conditions such as icing, snow, thunderstorm activity, turbulence, hail, etc. Most of these factors are variables. Some of these are controllable such as runway length and obstruction clearance, while others, like wind, temperature and humidity, are compensatable. Other factors such as thunderstorm activity, severe turbulence and hail are dealt with best by complete avoidance. However, factors such as low ceiling and visibility, icing, bird strikes and moderate turbulence must be met as they come.

One of the performance requirements, then, must be the ability of the airplane to ignore certain factors in its environment. Little success has been achieved in altering weather. Attempts at localized alteration of weather, such as FIDO for fog dispersal, have not proven feasible for commercial operation.

One manufacturer of washing detergents advertises that his product "doesn't soften the water—it ignores the hardness in the water." This same philosophy is applicable to aircraft where we attempt to provide anti-icing for ignoring light ice, pressurization for flying above turbulence, bird-proof windshields for resisting bird strikes, radar for by-passing areas of intense weather activity, etc.

If we were to continue the analysis, we would see that there has been either greater emphasis, or greater success, in the development of means of overcoming the *en route* portions of this, than there has been with those phases of the flight which occur on or near the ground.

We believe that greater emphasis must be put into successfully overcoming those factors which keep multi-million dollar machines parked at the ramp for lack of ceiling or visibility, even though they are completely capable of safely dealing with the elements from any point 200 feet above the runway. Obstruction clearance around airports and greater runway length together with more highly refined take-off and landing aids would drastically reduce this penalty which the air carriers and the public take at the whim of Mother Nature. The direct economic loss to the air lines is tremendous, but there is no means of evaluating those intangible losses of the traveling public through disrupted business plans and missed appointments.

Temperature And Humidity

Design engineers know that providing protection against most of the environmental conditions such as just enumerated, invariably results in a weight penalty. Aircraft designers are utilizing every means to get the last pound of gross weight and the last knot of speed out of their airplanes and still meet the minimum performance requirements of the regulations. We cannot object to that philosophy, for of such is made the competitive economic business of this country. Flight test methods used in obtaining the performance manual material are admittedly done under those conditions which will give the least penalty in the ultimate certification of the airplane. We do not mean to imply that such procedures are improper or irregular, or that the airplane is not capable of duplicating the same results *under the same conditions* at any time. But we have seen time after time that this is not necessarily an indication of what the airplane will accomplish at the *same gross weight* under the conditions it will encounter *at particular times* in its scheduled air line operations.

The present regulations do not provide for obtaining the same level of performance in the takeoff, climb, or approach-climb regime under even the normal variations in atmospheric conditions. The air line pilots are convinced that the good performance safety record that does exist, is the direct result of the reliability of the engine manufacturer's products, and is not due to the ability of the airplanes to meet the minimum performance requirements for safe flight under *all conditions encountered*. This will not be achieved until a method of performance evaluation, based on full temperature and humidity accountability, is applied to all transport airplanes, irrespective of the type of power plant being used.

To illustrate: one of our modern twin-engine transport airplanes has achieved rather impressive certificated performance in its takeoff configuration. This has been accomplished from a smooth, dry, hard surface runway, under standard air conditions at 2450 horsepower per engine. This produces a BMEP reading of 242, which is roughly a ratio of 10 HP/BMEP.

On a hot, humid day a pilot abandoned a takeoff because he was unable to exceed 208 BMEP on either engine. When he rejected the airplane as being unairworthy, maintenance and operations personnel brought out curves and charts to show that, at the existing conditions of temperature and humidity, one engine was actually exceeding the expected BMEP reading.

Again using our rough measure of 10 HP/BMEP, each engine was developing approximately 2080 HP of the 2450 HP needed to meet the single-engine performance requirements at that gross weight. And yet, according to the performance manual, that airplane requires 1900 horsepower to maintain level flight at V_2 in single-engine configuration.

Had those pilots lost an engine on that particular flight, they would have had approximately *180 HP* for climbing and for accelerating to sufficient airspeed to permit cleaning up the airplane and getting back around the field. Instead of the *550 horsepower* above that required for level flight, they would have had *less than one-third* the power necessary for meeting the performance requirements for that single-engine operation.

Because the one-engine out performance on a twin-engined airplane involves fifty per cent of the total available power, the all-engine performance becomes almost spectacular. It is easy for most people to forget that the only really critical horsepower is that ***above*** the amount required for level flight in that particular configuration. Had this pilot-in-command continued the takeoff, and had an engine *not* failed, there would have been available 2260 horsepower, *more* than the amount needed to maintain level flight. This would still have been enough to produce rather high 2-engine performance. But, *with one engine out,* the power available for climbing and maneuvering, on the same airplane, at the same gross weight, under the same conditions of temperature and humidity would have dropped from *2260 to 180* horsepower, or only 8% of that available had both engines continued to run. And yet the pilot was censured for having rejected the airplane because the book showed that the power output was slightly better than what the engine was supposed to produce under those conditions.

The air line pilots contend that the

same level of performance should exist at 4000 feet with a temperature of 115° and 80 per cent relative humidity as does at sea level under standard air conditions. The law of gravity has never been affected by temperature or humidity.

Adequate Airports

Adequacy of airports is needed for realistic performance. The public cannot be asked to depend upon the performance of the airplane alone in obtaining the level of safety they expect.

It is just as realistic a performance requirement to obtain 50 feet clearance over the obstacles at the end of the runway by moving that runway end sufficiently far from the start of the takeoff, or by lowering those obstacles, as it is to increase the performance ability of the airplane by reducing the gross weight.

Sufficient runway length must in itself be considered a means of meeting performance requirements. When considering the economic penalties that the air carriers and, through them, the general public are forced to absorb annually for the lack of an additional thousand feet of concrete at many major air terminals, one is appalled at the lack of long range planning and thinking which could terminate this condition. Representatives of the Air Line Pilots Association have met with U. S. manufacturers of all new airplanes produced since World War II. There has not been one single case in which, before the first half-day's discussions were over, someone had not made a comment to the general effect of: "This airplane can take off at Chicago Midway airport with an economically profitable pay load and fly non-stop to ——." This, the world's busiest airport, has restricted the design of all modern transports. These restrictions have definitely been performance restrictions.

Runway length is not in itself the only runway problem which vitally affects performance. For example, soft, black-top runways or undulating surfaces, pock-marked with chuck holes, have a deterring effect on performance. If you have had an opportunity to be near a takeoff runway at Chicago Midway airport on a hot summer day and watched the blacktop literally squeeze out from under the wheels as the airplane starts its takeoff roll, you would have cause to speculate on what factor of rolling drag should be applied over that of a hard surface runway. Or if, in taking off at Washington National during a drizzly rain driving across the runway, you were able to observe the ineffectiveness of the nose wheel in holding the airplane straight on the runway until rudder control speed has been reached, you would have reason to wonder what the efficiency factor should be over that which would be experienced on a dry runway. Or, consider the conditions which a pilot encounters when taking off from the rough, patched and re-patched, irregular surface of a runway. He is inclined to feel that the safest procedure is one in which he can, at almost any cost, get the wheels clear of the runway surface and stop pounding the airplane unmercifully.

Realistic Performance

The performance, as obtained during certification tests and which ultimately shows up in the performance manual in the form of gross weight allowances in the various configurations, is obtained upon smooth, dry, hard surfaces under the optimum conditions. The right takeoff procedures as evolved by the manufacturers for obtaining the manual performance at the certified maximum gross weight may not be practical under certain runway conditions which the air line pilot encounters. The factors used in determining the gross weight to be taken off of a particular runway involves temperature, wind, runway gradient and length. All too often a pilot has found himself in a situation during a takeoff wherein he is completely legal, the airplane is operating within the limits of its certification, and yet he as pilot-in-command is firmly convinced that, were he to lose an engine during that takeoff, he faces the very real possibility of a performance accident.

This condition is recognized by more than the pilot in the cockpit. In a safety memorandum issued February 1, 1956, the Flight Safety Foundation had this to say:

"There is a gap between aircraft engineering and aircraft operation. The manufacturer, in his zeal to produce an attractive load-carrying airplane, uses advanced engineering techniques and test flight procedures that obtain the ultimate from the aircraft.

"The operator has purchased an aircraft that is supposed to perform to certain numbers and his charts and operational plans are based upon this performance. But these techniques cannot be used an appreciably percentage of the time in actual air line operation. This compels the operating crew to work quite frequently under marginal conditions that are a compromise with safety.

"For example, consider the problem of takeoff and V_1-V_2 technique. We are taught that the only way to get maximum performance from the airplane is to leave the nose wheel on the ground until V_1 at least is reached, and preferably V_2 also. The airplane was certificated this way and will clear hazardous obstructions only if this technique is used. But, from the working pilot's viewpoint, consider the average runway he uses. In leaving the nose wheel on the ground until V_1 with the average rough runway, he is beating the aircraft structure unmercifully as he crashes and bangs down the undulating runway. Wincing at every blow, the pilot finally decides that hazarding an engine failure is less of an evil than collapsing the nose wheel, so he pulls the nose wheel off the ground. To the factory representative standing by, the pilot is using poor technique."

We contend that this is what is really happening. *The pilot* is being forced to make a split second evaluation of the lesser of two evils while completely preoccupied with the takeoff; *the operator* is being penalized by reduced pay load and increased maintenance costs. *The manufacturer* is compelled to beef up the airplane and the landing gear at an increased cost and weight penalty. And the *poor, unsuspecting passenger* is forced to pay indirectly for all of this while being subjected to a ride reminiscent of his early childhood days on the neighborhood trolley.

Human Element In Performance

Even though on every takeoff, an air line pilot anticipates the possibility of an engine failure or some other malfunction, the element of surprise if the takeoff *is* other than routine definitely has an adverse effect on achieving the ideal performance technique. This should be given consideration and receive compensation for day after day operations. The speed of the airplanes and the speed with which procedures are executed has continued to increase ever since the days the Wright brothers made their first flight. However, the human beings piloting these faster, heavier airplanes have not been altered a whit in their ability to see farther, use more hands, or think more than one thought at a time. Perhaps it is unfortunate that human society has not been interested in developing highly specialized hybrid humans for use as pilots in keeping up

with the developments of the machine itself. We have used selected breeding, inter-breeding, double crosses, and all the other gimmicks to produce dogs, chickens and horses for highly specialized purposes. However, since there is little chance that the old-fashioned process of falling in love with "the girl next door" will become obsolete as the first step in producing our future pilots, we should anticipate that they will be born with no improvements in human characteristics over those of today's pilots.

'Safety', A Requirement

One other consideration directly related to our definition of "performance requirements" concerns the possibility that, for some reason, the flight is *not* successfully completed under the conditions encountered. The "safety" component of the definition must be given full and careful consideration so that passengers and crew members have the maximum opportunity for survival.

An example of safety requirements which ALPA has continued to advocate for many years, concerns the emergency floatation equipment for air carrier operations not falling under the classification of over-water flights. Since as far back as 1948, the air line pilots have waged a constant battle to obtain requirements for emergency floatation equipment within the cabin area of all transports. From the first-hand knowledge of those crew members and passengers who have survived unintended ditchings, has come positive indication that very little in the way of floatation equipment would be needed to support an adult for the extra period of time which might be the difference between being saved and drowning. Every year the list of airplanes which are ditched for some reason continues to grow.

As the result of meetings with ALPA representatives, the Boeing Airplane Company has determined to its satisfaction that such equipment is necessary and desirable. They had made provisions to install it in their jet transport airplane before any change in the regulations was contemplated, and before the latest ditching on a non-over-water flight confirmed their beliefs. The Bureau of Safety Regulations of the Civil Aeronautics Board now recognizes this need, has completed circulation of a draft release on the subject, "Emergency Floatation Equipment for Air Carrier Operation," and is in the process of adopting regulations which will provide for such emergency floatation equipment.

The Economics Of Performance

The pilots do not in any way mean to imply that they are more concerned with safety than other segments of the industry, but would again point out that economics are frequently a dominant factor in evaluating items of performance and of safety. In many cases, the aftersight has substantiated the pilot's contention that the economics has been given a disproportionate value, and the dollars and cents actually involved to correct the shortcomings are lost many times over through accidents, loss of aircraft, and the loss of human life. Accidents cost money in many ways other than in loss of material or equipment. The air carriers know that a serious accident receiving widespread publicity will affect passenger revenue for a period varying from 30 days to six months. Flight

On The Cover

Interior view of Vertol 44B's cabin.

The Vertol Model 44, a 15- to 19-passenger tandem rotor helicopter, has been offered to air line operators, following its recent certification by the CAA. A product of the Vertol Aircraft Corp., it is a version of the company's H-21 "Work Horse" military helicopter.

The aircraft is available in three models: the 44A, for utility passenger-cargo operations with seating arrangements for 19 passengers; the 44B, for commercial passenger service with a 15-seat airliner configuration; and the 44C, an executive transport version.

Luxury Interiors

Shown on the cover are two 44B 15-passenger aircraft purchased by the French government. They feature chocolate brown seats with gold threads, deep pile beige carpeting, sand-colored walls and overheads, and aqua curtains. Each seat has its own adjustable air inlet and reading light.

The main cabin door is of clam-shell design, with built-in passenger steps and handrail. A second door at the front of the cabin is used for handling cargo.

Sound-Proof Cabin

The Vertol 44's sound-proof cabin is a constant cross-section area 20 feet long, 5½ feet high and 5 feet 8 inches wide. It has large oval windows.

Overall length of the aircraft is 52 feet 6 inches; overall height, 15 feet 5 inches.

The seven-ton helicopter has a useful load of 5,345 pounds. Its cruising speed is over 100 miles an hour, and its range with standard fuel reserve is 360 miles. The Wright Cyclone engine powerplant has a take-off rating of 1,425 hp.

High-Altitude Performance

According to the manufacturer, a two-speed engine supercharger provides for high-altitude performance in mountainous regions, enabling the Vertol 44 to take off from a 12,000-foot elevation with a 3,000 pound payload and carrying it 100 miles, maintaining the same altitude.

safety and economics go hand in hand, and yet on occasion it has been ignored till dramatic proof of the validity of this premise is presented in the form of accidents.

One air line had a fleet of high speed, 4-engine transports which were not equipped with reversing propellers even though the pilots had been attempting to persuade the company of the necessity of reversible propellers, and had predicted the inevitable result without them. By 1954, five airplanes had been substantially destroyed in landing run-out accidents with a direct loss of more than $6,000,000.00. The fleet could have been converted to reversing propellers for less than $1,500,000.00. After eight years of continued effort on the part of the pilots and after the severe losses had been taken, the propellers with the reverse thrust feature are in the process of installation.

The User's Viewpoint

The pilots believe that the finest and the safest airplanes in the world have been designed and built here in the United States. We do not, however, believe that even with that fine record have we fully met our definition of performance requirements, which is *the ability of the aircraft to exceed the minimum requirement for safe, successful flight under the conditions encountered.*

Let us re-emphasize that this is definitely not an attempt on the part of the air line pilot to find deficiencies in the manufacturer's product, in the carrier's operation of that airplane, or in the administration of the regulations covering the aviation industry. On the contrary, it is an attempt to present the thinking of the air line pilot, who, in the final analysis, must be considered as the ultimate user of the products of the aviation industry. As the pilot-in-command, he is not primarily concerned with meeting the airworthiness requirements as spelled out in the regulations while producing an airplane economically capable of competing with other airplanes, as is the manufacturer; or with an economically successful operation of the fleet, as is the operator; or in the responsibility of seeing that all airworthiness requirements have been met to provide the maximum protection for the public, as are the representatives of the regulatory agencies. And yet, he is vitally concerned with all of these aspects of the aviation industry and in air line flying in particular. Without an aircraft capable of safely and successfully completing its intended flight, the pilot would be without a job either as a result of the economic failure of his employer, or as a result of not having survived when the aircraft lacked sufficient performance for safe completion of the flight. The pilots are vitally concerned with contributing to the development of the best performance requirements possible.

The Air Line Pilots Association has, along with the rest of the industry, become acutely aware that its pilots' unique position of being the user of the products of aviation imposes both an opportunity and a responsibility upon it for supplying the type of detailed and specialized information which cannot be obtained as precisely, readily, or economically by any other means.

Every model of airplane that has been built to this day has at some time or other during its existence been tied up for modification of one type or another. Many of the modifications which grounded aircraft in the past could have been avoided had there been closer liaison between the regulatory agencies, the manufacturer, the air carrier, and the pilots who would be flying the aircraft. We believe that this is now recognized as a fact by all of the aviation industry.

The Air Line Pilots Association has specialized committees working on the various technical issues of aviation. These committees are staffed with men, who by interest, background, and training, are the best men qualified to evaluate the issues that ALPA can obtain. The complete resources of our Association are available to the aviation industry, without obligation. We are anxious to co-operate in every way.

Conclusions

We would like to urge consideration of more encompassing performance requirements for transport airplanes. They should improve existing concepts of performance requirements by insuring that all aircraft are capable of meeting a consistent, uniform level of performance under all conditions of:

- Atmospheric environment
- Deterioration of airplane or power plant
- Variations in human reactions.

They should consider factors other than those contained in the formal regulations as affecting performance, and thus, in effect, becoming performance requirements.

Special attention should be given to:

- Obtaining 50 feet clearance over the obstacles at the end of the runway under all conditions
- Increased runway length
- Adequate, obstruction-free airports.

The technical skills of the industry must continue to provide means for

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improving upon our good performance record. Air line safety and reliability is not something that has a beginning and ending, but is a nebulous and never-ending process that begins when an airplane is on the drafting table and continues as long as it flies.

(From a speech presented at the 25th Annual Meeting of the Institute of Aeronautical Sciences.)

Eye In The Sky . . .

(Continued from Page 5)

much more he can do, except to be sure that he makes good use of the time spent in scanning. He should scan systematically over the entire area from which threatening aircraft are most likely to come. Normally this will be the area fairly near the horizon. The distance he should scan on either side from dead ahead will depend somewhat on his own speed.

For very fast aircraft the greatest danger area is in a fairly narrow angle directly ahead. For slower aircraft the danger area extends much farther out to either side and includes the rear. The pilot should be careful to avoid spending too much time scanning a limited area, causing him to neglect other areas which should be covered.

Exterior Paint

Although exterior painting of aircraft might be considered as one solution to VFR collisions, it actually has little to offer. Black paint would improve somewhat the visibility against light backgrounds, as would white paint against dark backgrounds. But for either the black or white there will be (as for natural aluminum) some conditions of light and background where the contrast (and hence the visibility distance) is too low for collision avoidance. Use of colors—such as red, orange or yellow—likewise would not offer sufficient gain to justify their use, since, at extreme distances, the color is not visible. Even at closer range the color may not be visible if the observer sees the shaded side of the aircraft. Under special conditions of low brightness contrast, there would be some improvement of visibility from the use of colors such as orange or neon (fluorescent) red. These colors show up better than aluminum against the blue of the sky. But the overall benefits of any possible exterior painting are rather minor.

External lights on aircraft, as already mentioned, can be seen at great distances at night. Especially with the

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new rotating beacon type of anti-collision lights there is very little problem about VFR collisions at night.

Can lights also solve the problem in the daytime? It doesn't seem likely. The intensities required for collision lights to give adequate collision warning in daylight appear to make this solution prohibitive.

In summary, then, the human eye has some basic limitations which make it unreliable as a collision warning device under daylight VFR conditions. Very little seems possible in the way of improvement of visual detection through new or changed equipment. A better understanding of these limitations would help to avoid the hazards of mid-air collisions.

Computer Systems . . .

(Continued from Page 10)

quirements and economically practical to implement, include:

- Automatic detection of conflicts.
- Automatic assistance in the resolution of conflicts.
- Automatic runway scheduling for maximum capacity.
- Automatic flow control.
- Automatic transmission of data to aircraft (whether to pilot or to autopilot).
- Automatic exchange of data with operations offices, weather information centers, airport services, etc.

Compromise Needed

The basic problem in overhauling the ATC system is not in the lack of engineering capability, either in government or in industry. Nor does it lie in the lack of stated requirements from operational groups. The obvious difficulty has been the failure of the several airspace users to compromise on a set of system requirements possessing the essential ingredient of consistency. Thus, the engineering groups have been forced to waste a significant fraction of their effort in trying to predict what the upshot of the operational and political uproar was to be before they could even start on the task of preparing an engineering plan on an overall systems design basis.

It is very encouraging to note the increased emphasis, in the CAA and other branches of the government, on long-range implementation and on research and development projects designed to solve our current difficulties in ATC. It is even more encouraging to note the increase, during the past year or so, in the number of meetings in which diverse operational and engineering groups come together to discuss ATC requirements with an ever-growing spirit of cooperation. Let us hope that 1957 will measure up to the expectation that it will be the year of decision on the future direction of ATC development.

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